Children movement competence: Quantitative assessment through an instrumented version of the TGMD-2

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Introduction: Movement competence is defined as the development of sufficient skill and ability to assure successful performance in a variety of physical activities. Minor motor delays and/or low movement competence in childhood lead to low participation in physical activity, with consequent increased risk of obesity, cardiorespiratory and mental health outcomes [1]. Despite a high global attention on this topic, an overall decline in children's skill performance has been observed [2]. Clearly, there is need of effective interventions in order to improve these competencies in the young. To make this possible, it is necessary to have quantitative, interpretative and widely usable screening methods for identifying low movement competence in specific children. Despite the number of proposed batteries for movement assessment, no gold standard has been identified for testing. Moreover, when aiming at interpreting results evaluating movement strategies (e.g. using the test of gross motor development, TGMD-2 [3]), results are often operator dependent and test administration and evaluation are time-consuming, limiting a wide use of movement competence assessment. The present work aims at overcoming these limitations with the use of inertial sensors to quantify objectively children' movement competence in children. The aim of this work was to design and validate an instrumented version of the locomotor subtest of TGMD-2 in order to provide new quantitative tools for movement competence assessment based on wearable technologies.

Research Question: Can we assess children movement competence objectively and automatically using inertial sensors?

Methods: 60 typically developing children participated in the study: 20 6 year old -, 20 8 year old – and 20 10 year old children. Five tri-axial wireless inertial sensors (OPALS, Apdm, USA) were mounted on the lower back, on the ankles and on the wrists. Children were asked to perform the TGMD-2 locomotor subtest, which consists in 6 tasks (two trials per task): run, gallop, hop, leap, horizontal jump and slide. Inertial sensor data (acceleration and angular velocities, sample frequency = 128Hz) and videos were collected during the tests. An expert operator performed standard assessment of the different skills, analyzing videos of the tests and following the TGMD-2 guidelines. Using theoretical approaches and modelling hypothesis, different algorithms were defined to automatically evaluate the performance criteria based on inertial sensors' data. As an example, Table 1 shows TGMD-2 performance criteria for the Horizontal Jump and the corresponding algorithm principles for its automatic assessment. Percentage of success of the defined algorithms was calculated on all performed tests.

Table 1. Performance criteria and corresponding algorithm principles for the horizontal jump.

Performance criteria	Algorithm principles
Preparatory movement includes flexion on both knees with arms extended behind body	After identifying the instant of take off, ML angular velocities of the arms and of the legs are analyzed: velocities in the correct direction have to be present on both feet and legs prior to take off.
Arms extend forcefully forward and upward reaching full extension above the head	After identifying the instant of take off, ML angular velocity of the arms is analyzed: peak velocities have to be present in the period between take off and the middle of the flight.
Take off and land on both feet simultaneously	Foot off and foot landing instants are identified using the wavelet transform on the leg AP acceleration. A threshold of 0.08s (10 samples) is fixed for identifying simultaneous take off and land on both feet.
Arms are thrust downward during landing	After identifying the instant of foot landing, ML angular velocity of the arms is analyzed: peak velocities have to be present in the period between the middle of the flight and landing instant.

Results*:* Mean success calculated on the entire group of participants was higher than 88% for each skill. Algorithm failures happened mostly in 6-year-old children: when calculated only in this group, success rate showed minimum values of 70%.

Discussion: Preliminary results of the present study were promising. Improvement in algorithm percentage of success will be achieved adapting algorithms to different ages and/or to anthropometric data of the observed subject. The findings of these investigations will be relevant both for improving the reliability and usability of movement competence assessment and for improving our understanding on movement competence and motor control development during growth.

References:

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